



Distribution System Contamination Pathways and the Contaminants

**TCR/Distribution System
Webcast**

January 17, 2007



Overview

- Background Information on the Pathways through which Contaminants can Enter the Distribution System
- Contaminants of Concern



Contamination Pathways with External Sources

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Cross-Connections and Backflow

- **Cross-connections**

- Physical connections between potable water and a non-potable source that allow contaminants to enter the distribution system
- Often established intentionally without the user understanding the potential risks

- **Backflow**

- Reversal in flow when the pressure in the non-potable source exceeds the pressure in the potable water
- Pressure differentials are common occurrences even in well-maintained systems

- **Contamination can result during the simultaneous occurrence of an unprotected cross-connection and a pressure differential**

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Cross-Connections and Backflow



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Contaminants of Concern from Backflow

- **Range of Contaminants**

- Can come from many different sources and include metals, radionuclides, viruses, protozoa, bacteria (including indicators), hydrocarbons, and household and industrial chemicals

- **Common Chemical Contaminants**

- Pesticides (e.g., chlordane), herbicides, insecticides, detergents

- **Common Microbial Contaminants**

- Norovirus, *Giardia*, *Shigella*, *E. coli*, *Cryptosporidium*, echovirus, and other sewage organisms



Intrusion

- **Contaminants can Enter the System through Intrusion when Portals for Contamination Exist (e.g., leaks) and Low or Negative Pressures Occur**
 - It is common for water systems to lose more than 10% of finished water through leakage
 - Faulty joint seals and unprotected air vents can also allow entry of contaminated water
 - One survey showed that at least 20% of the surveyed systems have some piping located below the water table
 - Causes of low pressure may be common to distribution systems



Intrusion



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Contamination During Main Repair/Replacement

- **Main Repairs are often Conducted in Conditions Favorable to Contamination**
 - Return to service as quickly as possible
 - Trenches are flooded or below the water table
- **Estimated 237,000 Main Breaks per Year in the U.S.**
- **Estimated 13,200 Miles of New Mains Installed per Year in the U.S.**
- **Approximately 0.5% of Existing Pipe is Replaced each Year in the U.S.**

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Contamination During Main Repair/Replacement



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Contaminants of Concern from Intrusion and Main Repairs

- **Sewage Organisms**

- **In one study eight utilities sampled soil and water surrounding pipelines**
 - Viruses detected in 56% of samples, including the vaccine strain of Poliovirus, Norwalk and Hepatitis A
 - Fecal coliforms detected in approximately 50% of samples, with levels as high as 10,000/100 grams of soil

- **Pesticides**

- **Gasoline-Range Organics and Solvents**

- **Pharmaceuticals**

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Contamination Pathway with Both Internal and External Sources

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Covered Storage Vessels

- **External Contamination**

- Non-potable material could enter the system through deteriorated or improperly designed infrastructure
- One tank inspection firm reported that 20–25% of tanks have serious sanitary defects; 80–90% have minor sanitary flaws
- Human and animal access can also lead to contamination risks

- **Internal Contamination**

- Contaminants can accumulate in sediments, scales and biofilms and be released during hydraulic disturbances
- Aging of water during storage can lead to water quality problems, including the potential for Disinfection Byproducts (DBPs) formation
- Some contaminants can leach from improperly applied lining or coating material under certain water quality conditions

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Covered Storage Vessels



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Contaminants of Concern from Storage Vessels

- **External Contamination**

- Sewage organisms – e.g., *E. coli*, norovirus, *Cryptosporidium*

- **Internal Contamination**

- Biofilm organisms – e.g., *Mycobacterium avium* Complex, *Legionella*
- Disinfection byproducts
- Accumulated inorganics – e.g., radium, arsenic
- Leached organics and inorganics – e.g., cadmium, chromium, aluminum, vinyl chloride, polyaromatic hydrocarbons



Contamination Pathway with Internal Sources

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Biofilms

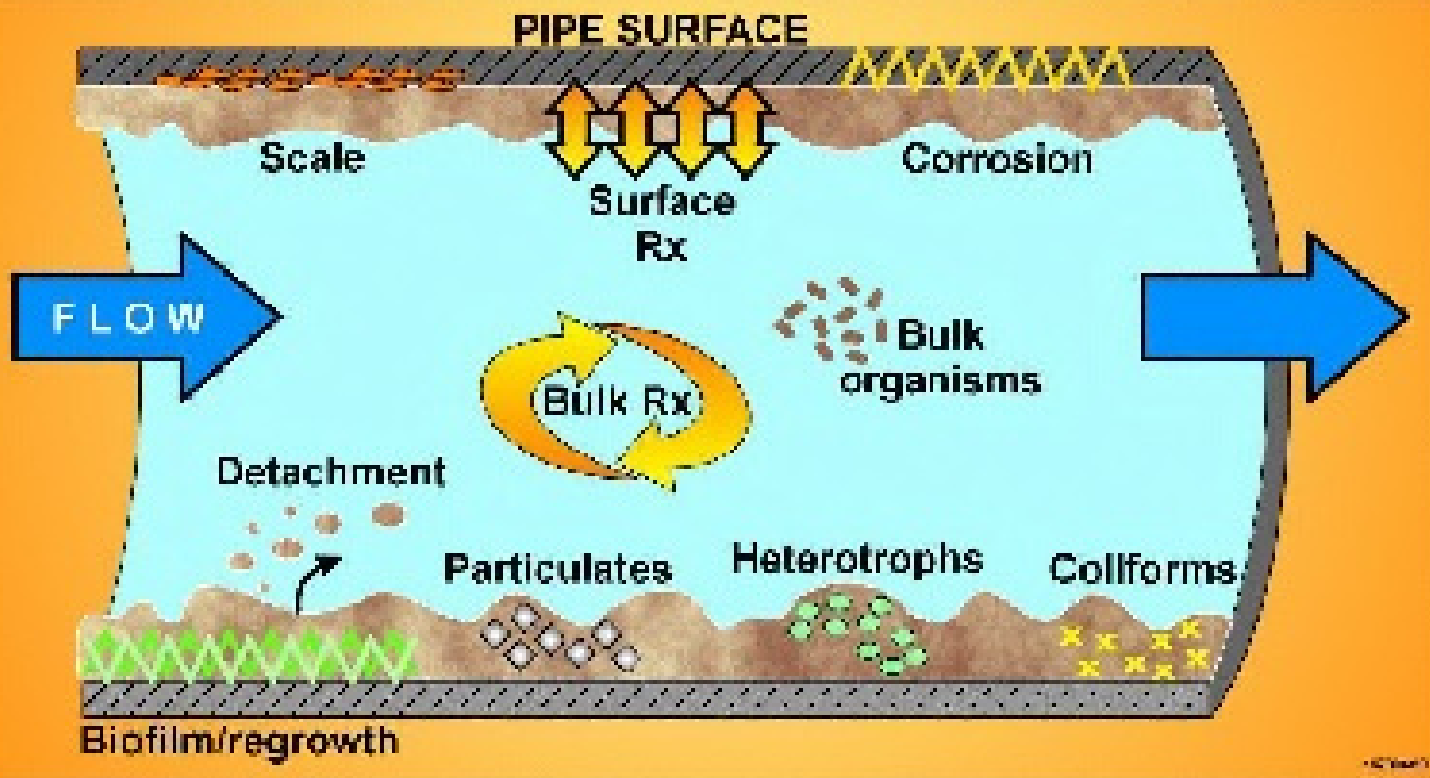
- **A complex mixture of microbes, organic and inorganic material attached to the inner surfaces of distribution systems**
 - Present in all distribution systems – typical to control, not eliminate
- **Some opportunistic pathogens grow within biofilms**
- **Some pathogens protected from disinfectants within biofilms**
- **Released during hydraulic or water quality disturbances**
- **Can also accumulate some chemical contaminants and microbial nutrients**

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Biofilms

The Distribution System as Reactor



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Contaminants of Concern in Biofilms

- **Opportunistic pathogenic bacteria capable of growth in biofilms**
 - *Legionella pneumophila*
 - *Mycobacterium avium* Complex (MAC)
 - *Pseudomonas aeruginosa*
- **Primary pathogens which have been found in biofilms, but may not necessarily grow include:**
 - *Helicobacter pylori*
 - *Escherichia coli*, some of which are pathogenic
 - Poliovirus 1
 - Coxsackie virus B
 - *Cryptosporidium*

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Other Issues of Potential Concern

- **Corrosion**

- Physicochemical process which releases metals (e.g., iron) from distribution system materials

- **Nitrification**

- Microbial conversion of ammonia to nitrite, then to nitrate

- **Leaching**

- Release of some chemical components (e.g., metals, vinyl chloride) from materials as a result of water quality changes

- **Inorganics accumulation**

- Accumulation of inorganics in scales, sediments and biofilms released during water chemistry or hydraulic disturbances

- **Permeation**

- Migration of hydrocarbons through plastic materials into the finished distribution system water

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